A G-Polygon Based Spatial Prescreening Technique and Its Application to AIRS Data

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Introduction

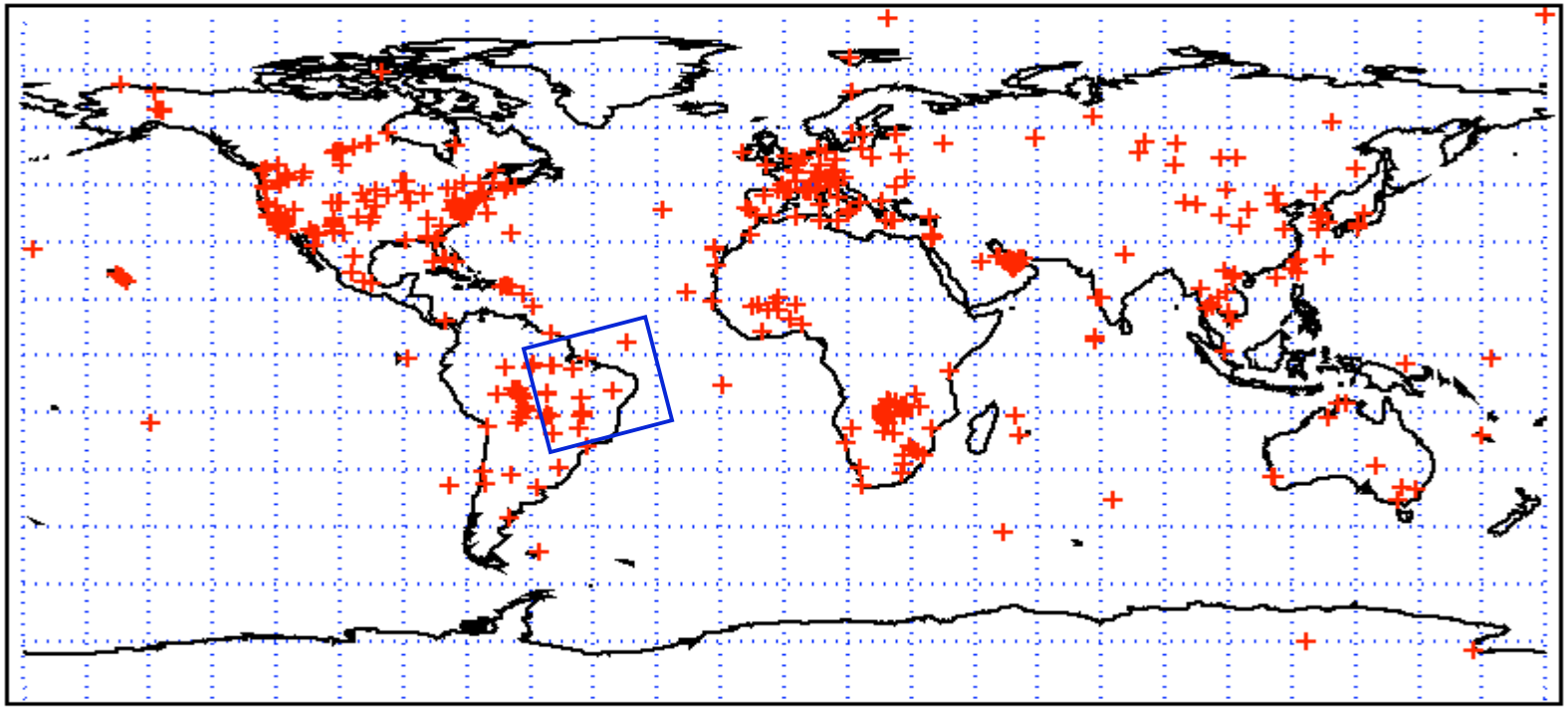
- Why prescreening?
- G-polygon vs bounding box
- An accurate prescreening technique
- Its applications to AIRS data

The technique is described in A Spatial Pre-Screening Technique for Earth Observation Data, IEEE Geoscience and Remote Sensing Letters, Vol. 4, No. 1, January 2007
by Xin-Min Hua, Jianfu Pan, Dimitar Ouzounov, Alecei Lyapustin, Yujie Wang, Krishna Tewari, Gregory Leptoukh and Bruce Vollmer,

Why prescreening?

- EOS instruments (MODIS, AIRS ……) provide data granules covering large spatial areas, on the order of 1000 km.
- Many researches (e.g. comparative studies, validation by ground observations ……) focus on regional processes, requiring much less than full granules.
- Researchers want to know in advance if a given data granule covers the locations of interest to them.

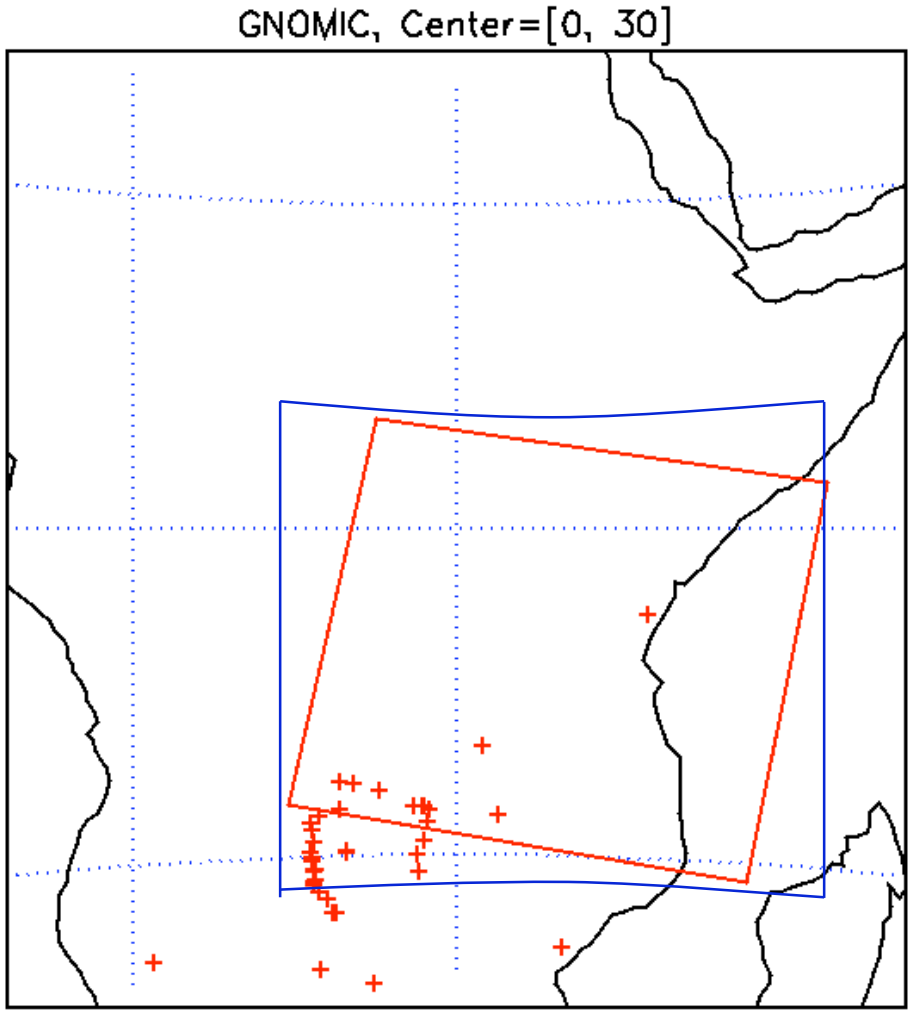
An example: AERONET stations



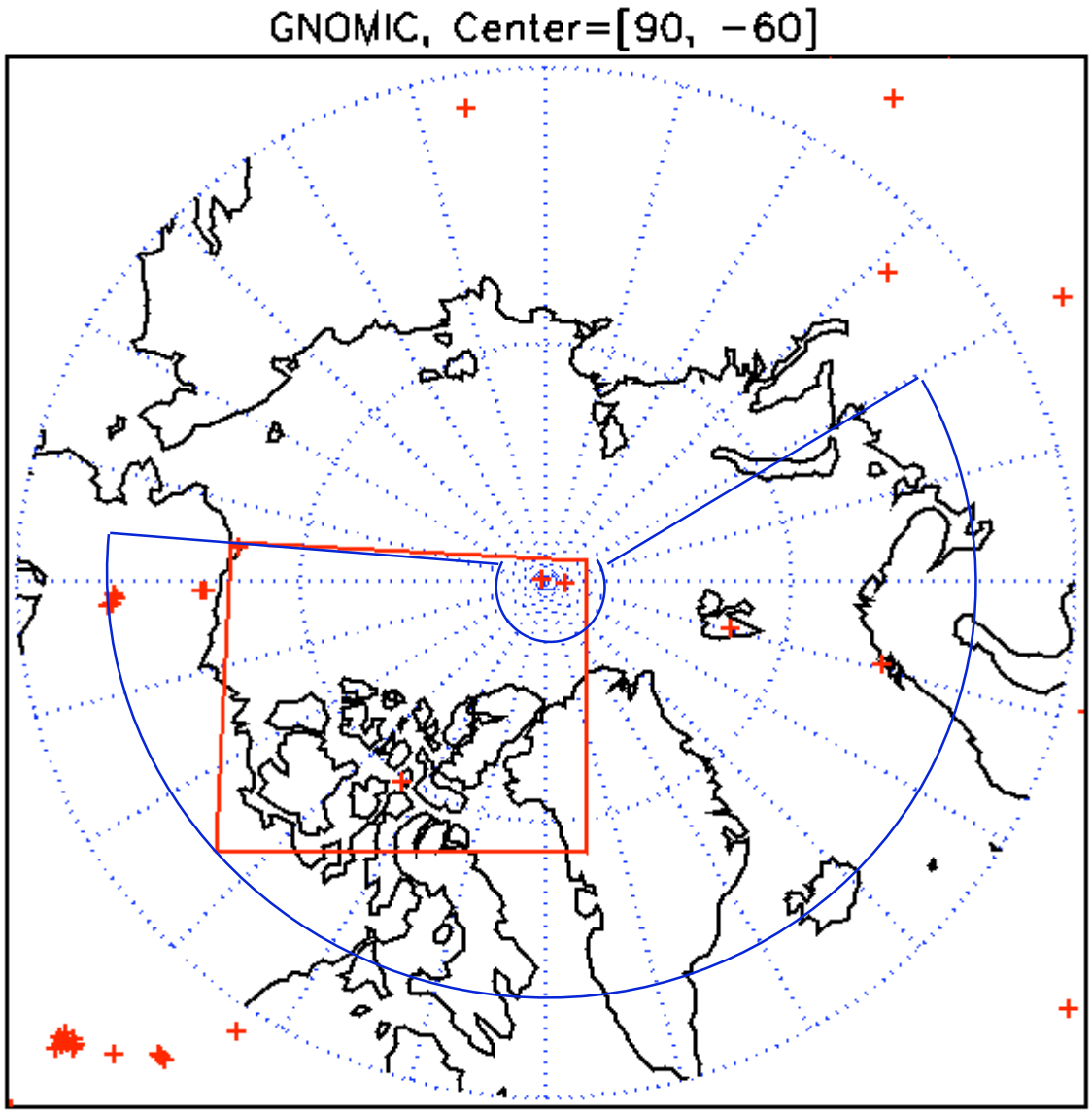
Options

- No pre-screening: pixel-by-pixel comparison – slow.
- Bounding box (Max./Min. lat/lon) – inaccurate, needs special treatment for high-latitude and dateline/pole crossing granules.
- An accurate prescreening algorithm, capable of handling all data granules uniformly, regardless of their locations on the Earth, with no special treatment required for dateline/pole crossing granules. – Too good to be possible?

G-polygon vs Bounding box



Example 1:
Bounding box
at low latitudes



Example 2: Bounding box
at high latitudes – crossing pole, dateline

An accurate prescreening technique

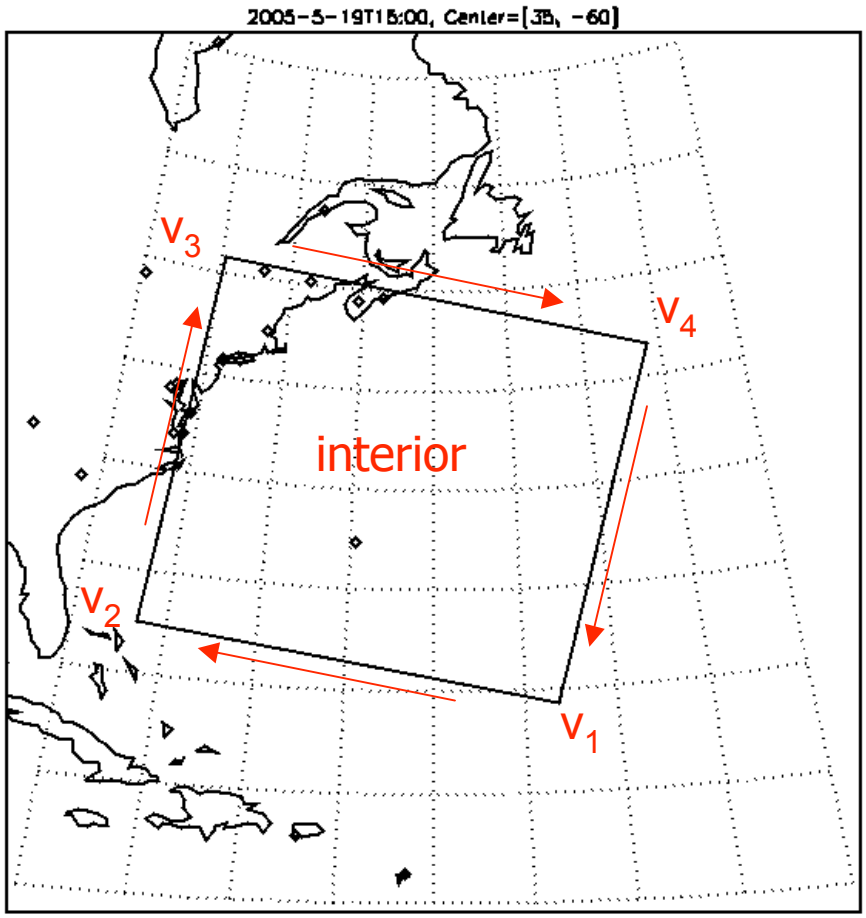
Definitions and Assumptions:

- Earth surface can be approximated by a sphere.
- An AIRS/MODIS granule (6/5 minutes) covers a rectangular region (swath) on the surface of Earth – approximated by 4-sided G-polygon.
- G-polygon -- polygon on a sphere with arcs of great circles as its edges.
- G-polygon divides the sphere into two domains – interior and exterior.
- Define the order of vertices of a G-polygon (G-Ring sequence) as follows: when one moves in the order along the boundaries, interior is always on the right-hand-side.

G-polygon: interior and exterior

Vertices order (G-ring sequence): 1-2-3-4-1

Clockwise !



Great circle equation

ϕ – longitude, θ – latutude

Great circle equation passing through point $p_1\ (\phi_1, \theta_1)$ and $p_2\ (\phi_2, \theta_2)$ with a direction from p_1 to p_2 :

$$f(\phi,\theta) = \tan\theta \sin(\phi_1 - \phi_2) + \tan\theta_1 \sin(\phi_2 - \phi) + \tan\theta_2 \sin(\phi - \phi_1) = 0.$$

Great circle divides sphere into three domains :

On great circle : $f(\phi,\theta) = 0$

On right - hand - side : $f(\phi,\theta) > 0;$

On left - hand - side : $f(\phi,\theta) < 0.$

Criterion for G-polygon interior

A swath with 4 corners:

$v_1(\phi_1,\theta_1)$, $v_2(\phi_2,\theta_2)$,

$v_3(\phi_3,\theta_3)$, $v_4(\phi_4,\theta_4)$.

Edges of the swath:

$f_i(\phi,\theta)=0,\ (i=1,2,3,4)$

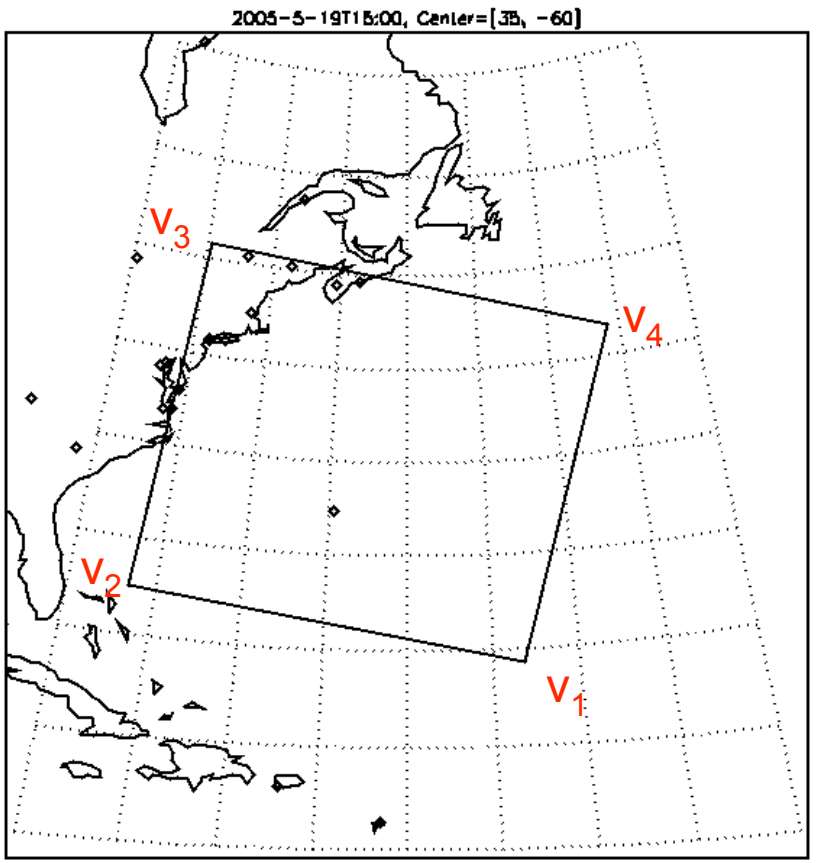
with $(v_1,v_2),(v_2,v_3),$

$(v_3,v_4),(v_4,v_1)$

replacing (p_1,p_2).

A point (ϕ,θ) is inside swath

if $f_i(\phi,\theta)>0$ for $i=1,2,3,4$

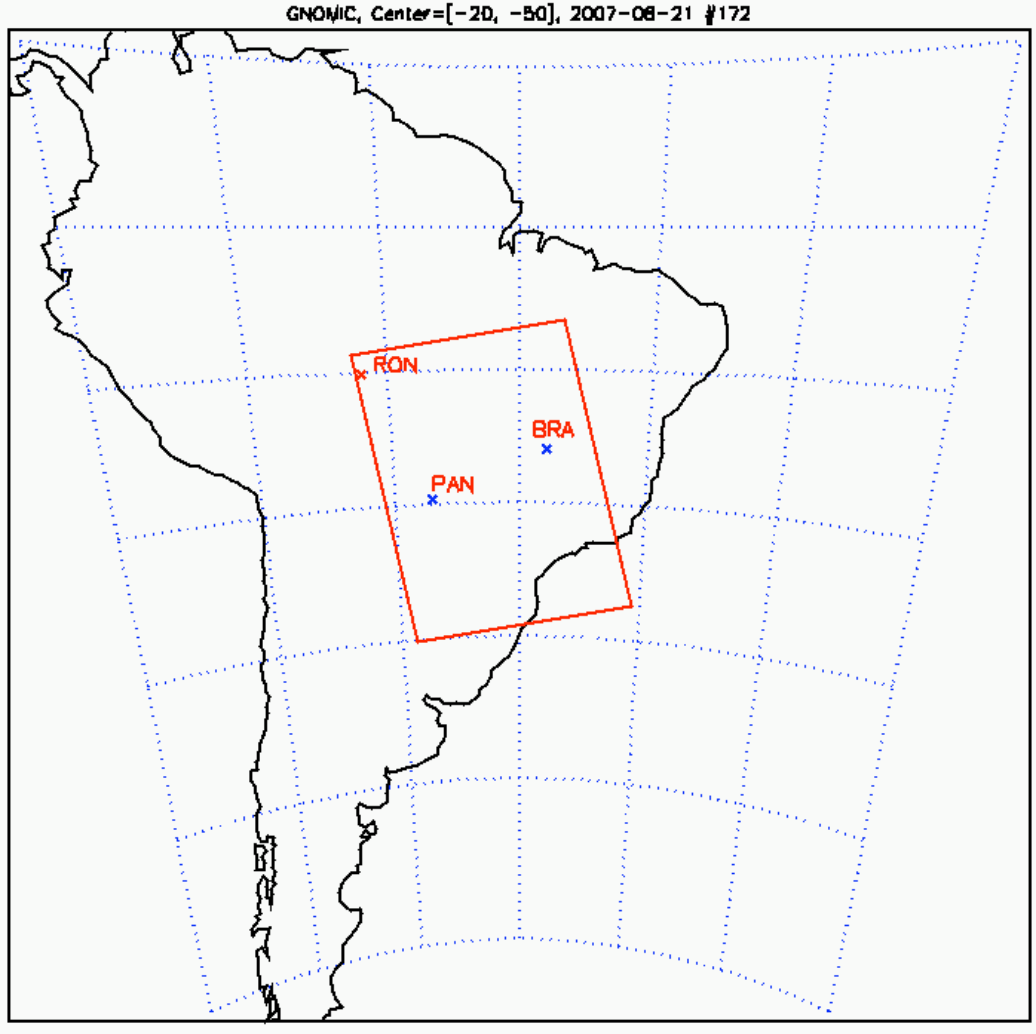


Application to AIRS data

Subsetting AIRVBRAD data for 36 sites in

Coordinated Enhanced Observing Period Data Management (CEOP)

Site	Lon	Lat
RON	-61.93	-10.08
BRA	-47.92	-15.93
PAN	-57.01	-19.56



AIRS geolocation information

AIRVBRAD data

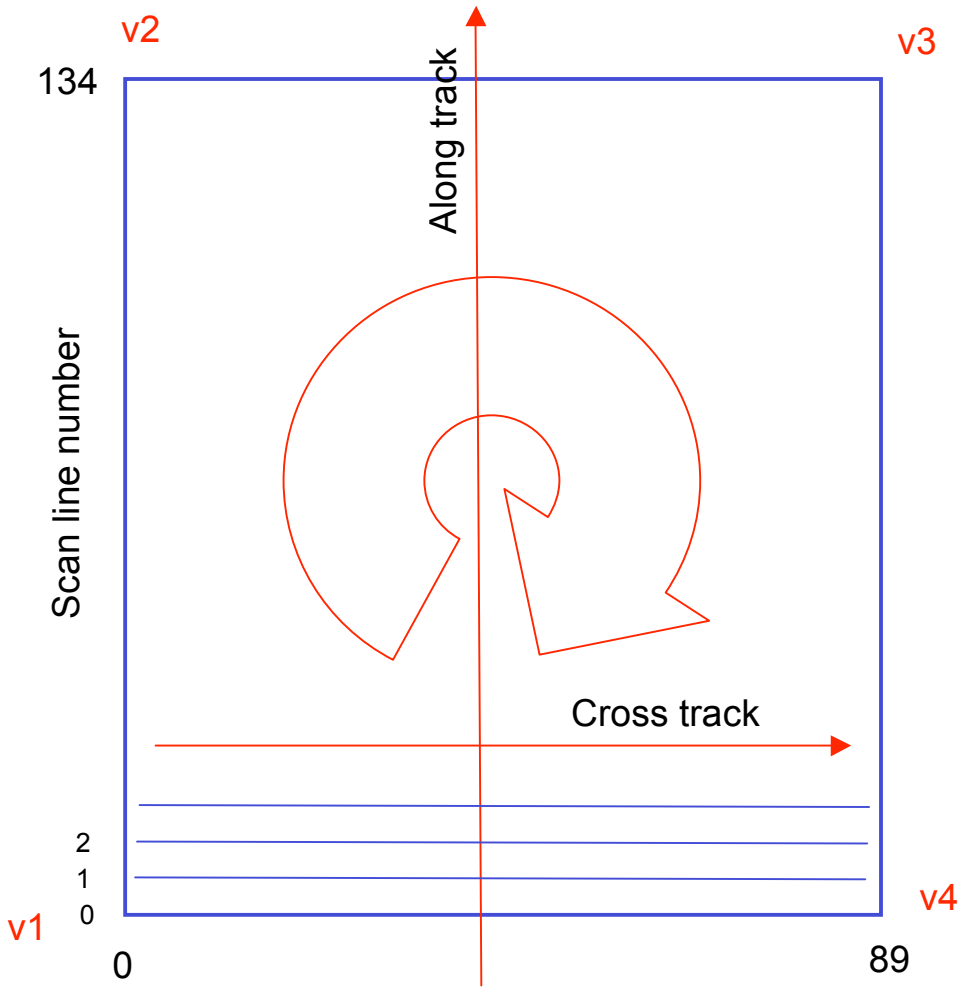
Geolocation information:

Longitude, Latitude

135 X 90 (=12150)

Vertices sequence:

Vertex	2-dim	1-dim
V1	[0,0]	[0]
V2	[134, 0]	[12060]
V3	[134, 89]	[12149]
V4	[0, 89]	[89]



Performance

CEOP AIRVBRAD subsetter using G-polygon based prescreening

Test on 406 granules of 2007.08.20, 21, 22

- Before --

Use bounding rectangle plus special treatments for dateline/pole crossing granules. Sometimes need to scan all pixels. Found 130 sites covered.

- After –

Only need to know lat/lon values of the 4 corners and blindly apply the technique. Treat all ground sites and granules equally. Found 131 sites covered.

Performance - accuracy

- Before –

false negative (all marginal):

2007.08.20 #181 PAN

2007.08.21 #074 EIS

2007.08.22 #119 NSA

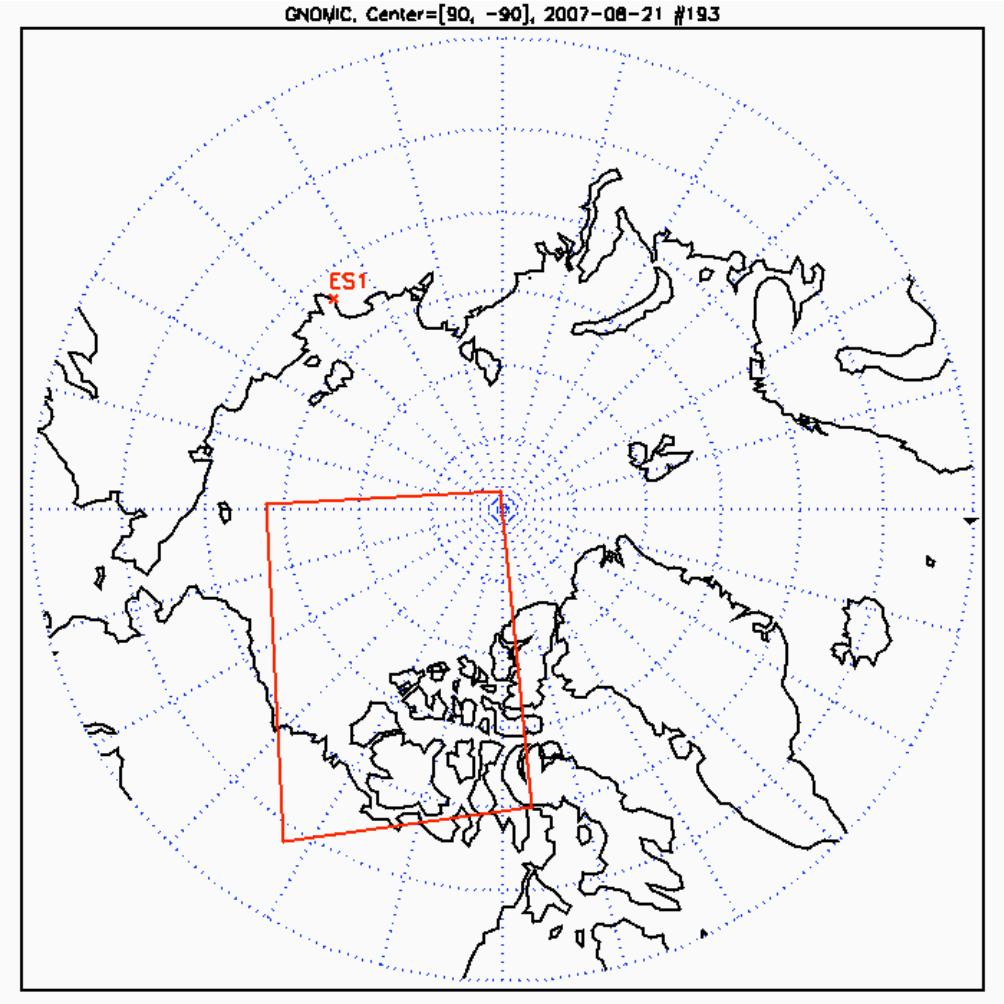
false positive:

2007.08.21 #160 ES1

2007.08.21 #193 ES1

- After --

No false positive, no false negative.



Performance - efficiency

CEOP AIRVBRAD subsetter using G-polygon based prescreening

Test on 406 granules of 2007.08.20, 21, 22

checkSitePos -- function checking if a granule covers any sites

Time profiling results:

- Before --

Computer time: 0.36 sec. 0.17 ms/call

- After –

Computer time: 0.03 sec. 0.01 ms/call

Over 10 times faster!

Conclusion

- Accurate, reliable and efficient pre-screening method.
- Treats all granules, ground sites equally. Cab be applied blindly as long as 4 corners are in clockwise order.
- Boundaries can be expanded or shrunk to meet users' special requirement on marginal sites. (see the paper)
- Recommended for Matchup PGEs, V6 planning.